NATICOOK LAKE

LAKE LAY MONITORING PROGRAM

1984

Freshwater Biology Group (FBG)

University of New Hampshire

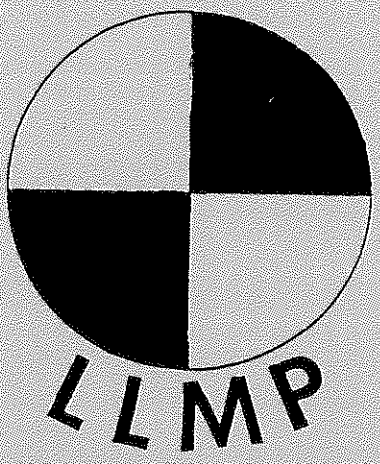
Durham

by

Kimberly J. Babbitt

Coauthored and edited by

A. L. Baker J. F. Haney



To obtain more information about the Lake Lay Monitoring Program (LLMP) please contact Dr. Baker at (603)-862-2060 or Dr. Haney at (603)-862-2100.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

Naticook Lake has been a part of the Lake Lay Monitoring Program (LLMP) since 1983. Through the efforts of Mr. David Soule and Mr. George May, the program continued strongly in 1984. Mr. George May was the sole monitor for Naticook Lake and provided boats for the field team.

We congratulate the lay monitors on the quality of their work and anticipate that the monitors will continue their efforts next year. We wish to thank Mr. Soule, Mr. May and all the members of the Naticook Lake Association for their time and effort in organizing the LLMP on Naticook Lake.

Members of our Freshwater Biology Group included Kim Babbitt, Matt Boyle, Chris Brown, Emily LeViness, Deb Thunberg and Jennifer Turner. Kim was team leader, and was responsible for coordination of field trips and data analysis and interpretation. Matt was responsible for phosphorus analysis, Chris for chlorophyll *a* analysis, Emily for phytoplankton, and Deb for zooplankton. All team members helped with data organization and filing, and also with field trips throughout the summer.

The Office of Computer Services kindly provided computer time and storage space for the Lake Lay Monitoring Program. The final text was set with Wordstar on Northstar and Zenith microcomputers, and printed on a letter-quality Spinwriter.

Brief Non-technical Summary

1) Naticook lake is oligotrophic (high water quality) on the basis of amounts of algae (low chlorophyll a) and low total phosphorus, and mesotrophic (moderate water quality) based on water clarity (Secchi disk depth).

2) High specific conductivity and chloride ion concentrations indicate high salt inputs. The likely source of salts in Naticook lake is road salt.

3) The pH of surface water was 7.0 on both FBG trips. Alkalinity levels were moderately high for New Hampshire lakes, but were lower than in 1983.

Comments and Recommendations for Naticook Lake

1) Monitoring for chlorophyll a concentration and Secchi disk depth should be continued on Naticook Lake. If possible, monitoring should begin in April or May, and should at least cover the entire summer (June-August).

2) Samples of total phosphorus and specific conductivity should be taken at the inlet and/or runoff sites to identify point sources. Samples should be taken after storm events, when inputs are likely to be greatest.

3) A program of lay monitor alkalinity (buffering capacity) and pH testing should be initiated to assess the effects of acid precipitation on the lake. It is important to establish a data base for alkalinity and pH in order to detect changes in these parameters as early as possible. This could be accomplished by training at least one lay monitor on the use of the pH meter and the chemical test for alkalinity. A workshop on "Testing for the Effects of Acid Precipitation" will be offered by the Freshwater Biology Group at the University of New Hampshire in late May or early June.

4) The extent of oxygen depletion (low) in Naticook Lake, as indicated by the LLMP is questionable considering data from the New Hampshire Water Supply and Pollution Control Commission that indicate more extensive depletion. Next year, and in years to follow, the program on Naticook should be designed such that a trip by the FBG is taken in July or early August. If feasible, a trip should be taken every month to best determine the extent of oxygen depletion, as well as the thermal stability of the lake.

5) To provide data on changes in water color throughout the season, we suggest lay monitors collect samples for dissolved water color. Water color decreases the water transparency, and thus effects the Secchi disk depth. A more accurate assessment of water quality based on Secchi disk depth can be made by knowing both the chlorophyll a concentration and the amount of dissolved water color. Water color samples consist of the filtrate from the chlorophyll a sample, and sampling can be done with essentially no additional cost. Details on the method for collection of dissolved water color samples will be provided on request.

Executive Summary for Naticook Lake 1984

1) Naticook Lake is oligotrophic based on low chlorophyll a concentration (avg. 2.1 micrograms per cubic meter) and low total phosphorus (avg. 8.6 micrograms per liter), and mesotrophic based on moderate Secchi disk values (avg. 3.8). Species concentration (1908-3474) and composition of phytoplankton indicate oligo-mesotrophic conditions. A bloom of algae in the metalimnion was composed mostly of Dinobryon, a species that is usually characteristic of lakes containing low phosphorus concentrations. Zooplankton densities were low (3-5 animals per liter), an indication of oligotrophic conditions.

2) The specific conductivity (avg 160 micromhos per centimeter) and chloride ion concentrations (avg. 22.3 parts per million) were high. High conductivity readings, coupled with low phosphorus, indicate that road salt is the main contributor.

3) The pH of near-surface water was 7.0. Alkalinity was relatively high (11.3 milligrams calcium carbonate) for New Hampshire lakes, but was lower than in 1983.

4) Oxygen concentration was high (above 7 ppm) in the hypolimnion on both trips, an indication of oligotrophic conditions. Erosion of the thermocline barrier was almost complete by the August FBG field trip, allowing mixing of the water column, and thus increased concentration of oxygen. Because of this, hypolimnetic oxygen depletion may be more extensive than indicated by FBG data.

METHODS OF LAY MONITORS

Lay monitors collected data on three parameters: thermal stratification, water clarity, and chlorophyll *a* concentration. Data were collected at weekly intervals whenever possible.

Thermal profiles were obtained by collecting lakewater samples at several depths with a modified Meyer bottle (Lind, 1979). Samples were obtained by lowering the empty but weighted bottle and sampling (by pulling out the stopper) at 1-meter intervals. The temperature of the samples was measured with Taylor pocket thermometers, and recorded in degrees Celsius.

Water clarity was measured while lowering an 8-inch (20 cm) Secchi disk and holding a view-scope just below the surface to eliminate the effects of surface reflection and wave-action. When the Secchi Disk disappeared the depth mark on the plastic suspension line was noted. The disk was raised until it just came into sight, and again the depth on the line was noted. The process was repeated two to three times, and an average between the two marks on the line (the point of disappearance and the point of re-appearance) was considered to be the Secchi Disk Depth (SDD), measured to the nearest one-tenth meter (0.1 meter) -- as for example, 5.2 meters. Readings were generally taken between 9 a.m. and 3 p.m., the period of maximum light penetration.

Chlorophyll *a* concentration was used as an estimator of algal biomass. A weighted tube 33 feet (10 meters) in length was used to collect an integrated water sample from the 'upper-lake' (epilimnion). The weighted end of the tube was slowly lowered to the interface of the epilimnion and the 'middle-lake' (metalimnion). The end of the tube was then bent double to shut off flow of air and water, and the weighted end of the tube (presently at the base of the epilimnion) was pulled up to the surface with a plastic line attached to it. The water in the tube (epilimnetic lakewater sample) was poured into a plastic bottle by placing the weighted end of the tube into the neck of the bottle and, while keeping the bent-off end above the weighted end, unbending the upper end (allowing the sample to discharge into the bottle).

Water samples were filtered through a membrane filter with a porosity of 0.45 microns. The damp filters containing chlorophyll-bearing algae were air dried for at least 15 minutes to prevent decomposition. Filtration and drying were done in the shade to minimize destruction (by bleaching) of chlorophyll. The dried filters were then sent to UNH for analysis. [In Durham, members of the Freshwater Biology Group extracted chlorophyll in 90% acetone saturated with magnesium carbonate, and read the absorbance of the sample at standard wavelengths (663 and 750 nanometers).

METHODS OF FRESHWATER BIOLOGY GROUP (FBG) TEAM

The same as well as additional parameters were investigated by the FBG research team. The additional factors were primarily measurements of sunlight penetration into the lakewater, and water chemistry. The latter included dissolved oxygen, 'free' (unbound) carbon dioxide, pH, specific conductivity, chloride ion, and total phosphorus. In addition, the microscopic plants (phytoplanktonic algae) and animals (zooplanktonic invertebrates) were identified. Relative or absolute counts were made.

Dissolved oxygen and temperature were measured with a Yellow Springs Instruments Model 54A Oxygen/Temperature meter with a submersible probe. Readings were taken at 1-meter intervals throughout the 'upper-lake' (epilimnion) and 'lower-lake'(hypolimnion), and at half-meter intervals through the 'middle-lake' (metalimnion).

Sun- and skylight penetration into the lakewater was measured at 1-meter intervals with a Whitney submersible photometer model LMA-8A, and the relative light intensity was recorded. Measurements were taken on the sunny side of the boat.

Dissolved water color was measured by reading the absorbance of filtered lakewater (0.45 micron) at 440 and 493 nanometers, in a Bausch and Lomb Spectronic 710 with a 15 cm path length.

Water chemistry (alkalinity, 'free' (unbound) carbon dioxide, pH, and specific conductivity and chloride ion) samples were collected with a 3-liter Van Dorn bottle. Alkalinity, free carbon dioxide and pH samples were stored on ice in 250 ml polyethylene bottles, and were analyzed in the field within 1 to 2 hours. Specific conductivity and chloride ion samples were analyzed in the lab, at room temperature.

Alkalinity was determined titrimetrically with 0.002 N sulfuric acid to a final pH of 4.5, with a combination solution of the two dyes bromocresol green and methyl red as the end-point indicator (E.P.A.,1979). Alkalinity is expressed as equivalents of calcium carbonate.

Free (unbound) carbon dioxide concentration was determined by titrating the fresh lakewater samples with 0.0027 N NaOH to a final pH of 8.3, and with the dye phenolphthalein as the end-point indicator.

Lakewater pH was measured with a digital pH meter (Orion model 231) equipped with a combination probe (Orion Co.).

Specific conductivity was measured with a Barnstead Conductivity Bridge Model PM-70CB equipped with model B-10 probe (cell constant = 1.0). Correction for sample temperature was made with a standard curve.

Chloride ion concentration was measured with a pH meter (Corning Model 10) equipped with a chloride electrode (Orion model 94-17B) and a double junction reference electrode (Orion Model 90-02). Standard curves were prepared every 2 hours during laboratory analysis.

Samples to be analyzed for total phosphorus, phytoplankton, and chlorophyll a were collected with a vertical 'tube' sampler. Chlorophyll a samples were filtered, dried and analysed in the same manner as those collected by lay monitors.

Total phosphorus samples were stored on ice in acid-washed 250 ml polyethylene bottles, and were fixed within 1 to 2 hours with 1.0 ml concentrated sulfuric acid. In Durham, the FBG members digested the total-phosphorus by adding ammonium persulfate and auto-claving the samples for at least 45 minutes. Finally, the phosphorus content of the samples was analyzed with the single-reagent method that included a fresh solution of ascorbic acid and potassium antimony tartrate (E.P.A., 1979). Absorbance of the blue phosphorus complex was measured spectrophotometrically at 650 nm.

Phytoplankton samples were fixed with iodine (Lugol's Solution) in the field, within 1 to 2 hours after collection. Phytoplankton were counted with a Unitron 'inverted' microscope after settling the samples for 24 hours in counting chambers. At least 200 individual algal 'units' were counted with a modified scan technique (Baker 1973).

Zooplankton density was estimated in samples collected by towing up a plankton net (30 cm diameter, 150 micron porosity) through the oxygenated (>0.5 ppm) portion of the lake. Samples were fixed after collection with a 4% formalin-sucrose solution (Haney and Hall,1973), and subsampled with a 1-ml Hensen-Stemple pipet. Sufficient subsamples were taken to insure that at least 100 microcrustaceans were counted.

RESULTS AND DISCUSSION OF LAY MONITOR DATA

Lay monitor research was conducted separately from Freshwater Biology Group (FBG) research, thus the results are presented separately. One sampling site was active on Naticook Lake in 1984 (Fig. 1). The lay monitor data for 1984 are presented in Appendix A.

Lay monitors collected information on three parameters: water transparency (Secchi disk depth), productivity (chlorophyll *a*), and thermal stratification. Information on thermal stratification is used primarily to determine the sampling depth of the chlorophyll *a* sample.

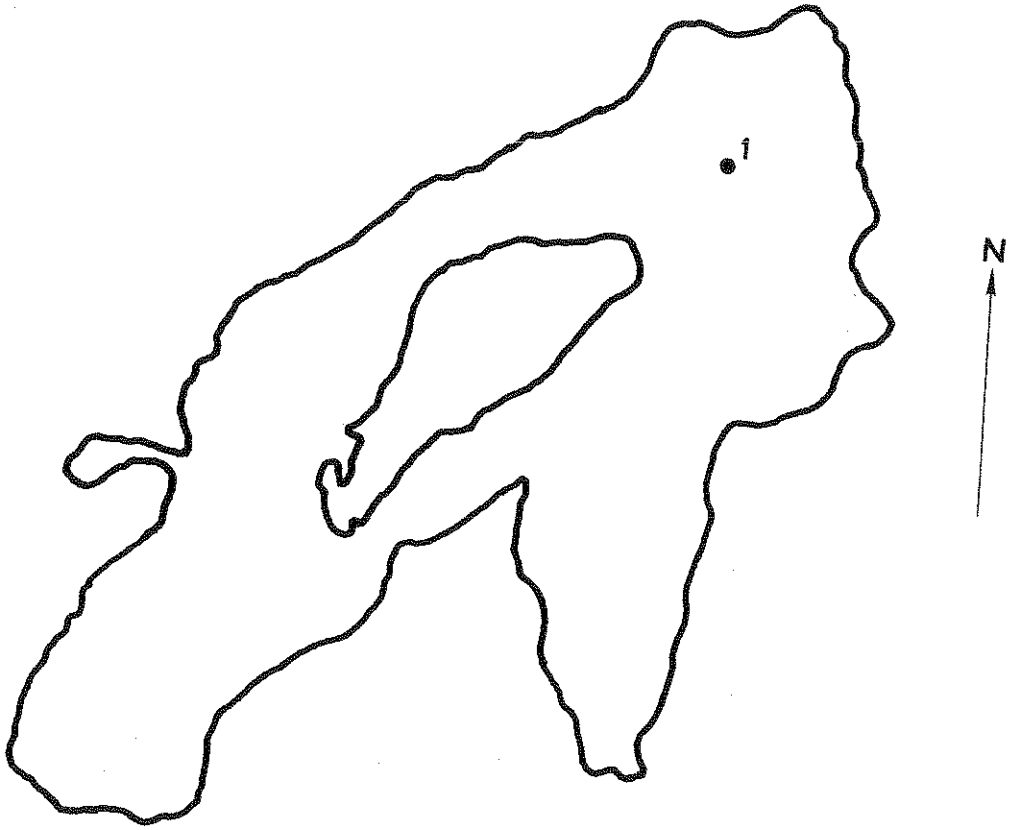


Figure 1. Naticook Lake, Town of Merrimack, New Hampshire. Outline map and location of 1984 sampling sites.

Secchi Disk Depth and Chlorophyll a Concentration (Lay monitor)

The water clarity on Naticook Lake was moderate, with an average Secchi disk depth of 3.8 meters (not including readings that bottomed out). Generally, water clarity increased over the summer (Table 1). The average chlorophyll a concentration in the lake was low, 2.1 milligrams per cubic meter. Chlorophyll a values tended to decrease over the summer (Table 1). A slight increase in chlorophyll a values was seen in mid-August. This may be due to an increase of algal productivity in the epilimnion, or from algae in the metalimnion moving up into the epilimnion. Secchi disk depths were shallower this year and chlorophyll a concentrations were higher than in 1983. More data is needed to determine if this is due to year to year variations or if lake water quality is decreasing. Naticook Lake would be classed as mesotrophic based on Secchi disk depth, and oligotrophic based on chlorophyll a concentration.

Table 1. Comparison of Secchi disk depth (SDD) and chlorophyll a (chl a) ranges and means for 1984 (BO= bottomed out). (SDD=meters, Chl a=milligrams/cubic meter)

		Range	Mean
July	SDD	3.3-4.3	3.7
	Chl a	1.4-3.1	2.4
Aug	SDD	3.6-4.4	3.9
	Chl a	1.0-2.7	2.0
Sept	SDD	---	BO
	Chl a	---	1.2

RESULTS AND DISCUSSION OF FRESHWATER BIOLOGY GROUP DATA

Temperature and Dissolved Oxygen (FBG)

Naticook Lake was thermally stratified on both FBG field trips (June 28 and August 28), but in August the epilimnion extended nearly to the bottom. Oxygen concentrations were high (above 7 ppm) except in the last half meter of water. A study done in July of 1979 by the New Hampshire Water Supply and Pollution Control Commission showed oxygen depletion in the hypolimnion. Such oxygen depletion would indicate more eutrophic conditions than were indicated by the LLMP study in 1983 or 1984. By the August sampling date erosion of the thermocline barrier was almost complete. This allows increased mixing, and thus increased oxygen concentration throughout the column.

On June 28, an oxygen peak was observed in the metalimnion. This is probably due to a bloom of algae in that region (see section on phytoplankton).

Water Clarity and Dissolved Color (FBG)

Secchi disk depths measured by the FBG were comparable to those found by the lay monitors. In June, the Secchi disk depth was 3.5 meters and in August 3.6 meters. These values would place Naticook Lake in the mesotrophic range. Dissolved water color increased slightly from .022 -.024, and was similar to values found in 1983. This change in water color is much less than changes found in other lakes in the LLMP, indicating that water color in Naticook Lake is relatively stable.

Chlorophyll a (FBG)

Chlorophyll a concentrations measures by the FBG were 1.4 milligrams per cubic meter in June and 2.0 milligrams per cubic meter in August. These values would place Naticook in the oligotrophic range.

Total Phosphorus

Total phosphorus is usually the most limiting (least abundant) nutrient to algae in freshwater systems. Phosphorus regulates algal productivity and therefore regulates chlorophyll a concentration, and indirectly (through chlorophyll a) influences water transparency. Increases in algal growth may occur with increases of phosphorus loading. Total phosphorus concentrations were low, ranging from 8.1-9.1 micrograms per liter. These values are similar to values found in 1983, indicating that phosphorus loading into Naticook Lake is low. Based on total phosphorus, Naticook would be classed as oligotrophic.

Alkalinity, pH, and Free Carbon Dioxide

The pH value of near-surface water was 7.0 on both FBG field trips. Alkalinity for near-surface waters averaged 11.3 milligrams calcium carbonate. Alkalinity values this year were lower than values found in 1983. More data is needed to determine if a trend in decreasing alkalinity is developing in Naticook Lake.

Free carbon dioxide accumulated in the hypolimnion, decreasing the pH of the lakewater in that depth zone. The low amount of accumulated free carbon dioxide indicates low productivity.

Specific Conductivity and Chloride Ion

Specific conductivity values from all dates and all depths were high, with an average of 160 micromhos per centimeter. The chloride ion concentration was also high, with an average of 22.3 parts per million. These values indicate high inputs of road salt and/or raw sewage. Considering low phosphorus values, the likely source is road salt.

Phytoplankton

The concentration of phytoplankton was low in June (1908 cells per milliliter) and moderate in August (3474 cells per milliliter), an indication of oligotrophic to mesotrophic conditions. The dominant phytoplankton groups in June were the Chrysophyceae (Dinobryon), Cryptomonads (Cryptomonas) and Chlorophyceae (Chlamydomonas). In August, the Cyanophyceae (blue-green bacteria) were abundant (along with the Chrysophyceae and Chlorophyceae), and the Cryptomonads were less abundant. The Chrysophyceae were the most abundant group on both trips. A phytoplankton sample taken in June from the area of the oxygen peak revealed a high density of Dinobryon. Algal blooms are usually found in more nutrient rich lakes; however, Dinobryon are characteristic of systems with low concentrations of phosphorus. Light penetration into the metalimnion in Naticook Lake increases the chance of metalimnetic blooms.

Zooplankton

The density of herbivorous crustacean zooplankton was low (3-5 animals per liter). *Daphnia* were dominant in June, and in August dominance shifted to calanoid copepods and the cladoceran *Diaphanosoma*. Densities were much lower this year than in 1983. Higher chlorophyll *a* values this year may be in part due to the lower density of herbivorous zooplankton.

REFERENCES

Baker, A. L. 1973. Microstratification of phytoplankton in selected Minnesota lakes. Ph. D. thesis, University of Minnesota.

Haney, J. F. and D. J. Hall. 1973. Sugar-coated Daphnia: a preservation technique for Cladocera. Limnol. Oceanogr. 18:331-333.

Lind, O. T. 1979. Handbook of common methods in limnology. C. V. Mosby, St. Louis.

New Hampshire Water Supply and Pollution Control Commission 1981. Classification and priority listing of New Hampshire Lakes. Staff report no. 121. Concord, New Hampshire.

U.S. Environmental Protection Agency. 1979. A manual of methods for chemical analysis of water and wastes. Office of Technology Transfer, Cincinnati. PA-600/4-79-020.

APPENDIX A

LLMP 1984 -- Lay Monitor Data: Naticook Jan-29-85 14:59.23

Date	Lake	Site	SDD	Chl
Jul-05-84	Naticook	1 Deep	3.60	3.07
Jul-11-84	Naticook	1 Deep	4.30	3.05
Jul-19-84	Naticook	1 Deep	3.30	1.93
Jul-25-84	Naticook	1 Deep	3.50	1.43
Aug-03-84	Naticook	1 Deep	3.90	2.07
Aug-08-84	Naticook	1 Deep	3.60	2.35
Aug-15-84	Naticook	1 Deep	3.70	2.68
Aug-24-84	Naticook	1 Deep	4.40	1.03
Sep-16-84	Naticook	1 Deep	---	1.22

>>> END OF LIST <<<